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GEODESY.—*On the size of the block of the earth's crust which may be independently in isostatic equilibrium.* WILLIAM BOWIE, U. S. Coast and Geodetic Survey.

As investigations in the theory of isostasy progress, we are better able to apply it to geology and the processes at work in the earth's crust.

When he was preparing data for Special Publication No. 10,[1] George R. Putnam, then a member of the Coast and Geodetic Survey, suggested that a test of regional versus local distribution of compensation should be made. This was done for 44 stations in the United States and for 4 foreign stations. The outer limits for the regional distribution were about 19, 59, and 167 kilometers, or about 12, 37, and 104 miles in all directions from the stations. In Special Publication No. 40,[2] the data for the 44 stations were reprinted and similar data for 80 more stations in the United States were added. For purposes of study, these stations were then divided into groups according to the topographic form on which they are located. As was to be expected, only the stations in mountainous regions gave any appreciable difference in the anomalies for the different distributions of the compensation. The following summaries are taken from Special Publication No. 40 (pages 90—91) where detailed results are given:

If the most reasonable distribution is that which most nearly eliminates the gravity anomalies, we should study the data to see which one best fulfills the requirement.

[1] J. F. Hayford and W. Bowie, *The effect of topography and isostatic compensation upon the intensity of gravity*, U. S. Coast and Geodetic Survey, Special Publication No. 10. 1912.

[2] W. Bowie, *Investigations of gravity and isostasy*, U. S. Coast and Geodetic Survey, Special Publication No. 40, pp. 85-87. 1917.

A careful analysis indicates that there is no choice between the distribution locally and the distribution regionally to 12 miles, and to 37 miles. This is shown both by the individual anomalies as given in Special Publication No. 40, and by the mean anomalies with and without regard to sign in the summaries above. But when the anomalies for regional distribution to 104 miles are inspected, it is found that there are larger anomalies than for the other distributions and the means with and without regard to sign are larger than for the others.

TABLE 1.—ANOMALIES FOR 22 STATIONS IN MOUNTAINOUS REGIONS AND BELOW THE GENERAL LEVEL

| | LOCAL COMPENSATION | REGIONAL COMPENSATION TO | | |
|---|---|---|---|---|
| | | 12 miles | 37 miles | 104 miles |
| | *dyne* | *dyne* | *dyne* | *dyne* |
| Mean with regard to sign | 0.000 | +0.001 | +0.003 | +0.006 |
| Mean without regard to sign | 0.017 | 0.017 | 0.018 | 0.019 |

TABLE 2.—ANOMALIES FOR 18 STATIONS IN MOUNTAINOUS REGIONS AND ABOVE THE GENERAL LEVEL

| | LOCAL COMPENSATION | REGIONAL COMPENSATION TO | | |
|---|---|---|---|---|
| | | 12 miles | 37 miles | 104 miles |
| | *dyne* | *dyne* | *dyne* | *dyne* |
| Mean with regard to sign | +0.003 | +0.003 | 0.000 | −0.010 |
| Mean without regard to sign | 0.018 | 0.018 | 0.017 | 0.020 |

As the compensation of the topography extends to a great depth below the surface, of the order of magnitude of 60 miles, it is seen that the computed effect is practically the same whether it is distributed for a reasonable distance around the feature or is directly beneath it.

If the data referred to above were the only direct or indirect evidence available, we should conclude that nothing could be said in favor of any particular horizontal distribution out to a distance of about 60 miles from the topographic feature.

It is worthy of mention that George R. Putnam, who was the first to make a quantitative test of the theory of isostasy, has held that the regional distribution of compensation is nearer the truth than local distribution.[2]

[2] G. R. Putnam, *Condition of the earth's crust and the earlier American gravity observations*, Bull. Geol. Soc. Amer. **33**: 287–302. 1922.

TABLE 3.—EFFECT OF GRAVITY ANOMALIES OF THE COMPENSATION FOR INNER ZONES

| NUMBER AND NAME OF STATION | ELEVATION H | ISOSTATIC ANOMALY | COR. TO DISCARD COMP. OUT TO AND INCLUDING | | ANOMALIES WITH ISOSTATIC COMP. OMITTED TO | |
|---|---|---|---|---|---|---|
| | | | 17.9 miles | 36.5 miles | 17.9 miles | 36.5 miles |
| | *meters* | *dyne* | *dyne* | *dyne* | *dyne* | *dyne* |
| 41 Wallace, Kans | 1005 | −0.012 | −0.027 | −0.048 | −0.039 | −0.060 |
| 42 Colorado Springs, Colo | 1841 | −0.007 | −0.054 | −0.094 | −0.061 | −0.101 |
| 43 Pikes Peak, Colo | 4293 | +0.021 | −0.070 | −0.113 | −0.049 | −0.092 |
| 44 Denver, Colo | 1638 | −0.016 | −0.038 | −0.076 | −0.054 | −0.092 |
| 45 Gunnison, Colo | 2340 | +0.020 | −0.063 | −0.120 | −0.043 | −0.100 |
| 46 Grand Junc., Colo | 1398 | +0.024 | −0.041 | −0.082 | −0.017 | −0.058 |
| 47 Green River, Utah | 1243 | −0.021 | −0.033 | −0.067 | −0.054 | −0.058 |
| 48 Pleasant Val. Junc., Utah | 2191 | +0.004 | −0.060 | −0.103 | −0.056 | −0.099 |
| 49 Salt Lake City, Utah | 1322 | +0.010 | −0.040 | −0.075 | −0.030 | −0.065 |
| 50 Grand Canyon, Wyo | 2386 | −0.002 | −0.061 | −0.108 | −0.063 | −0.110 |
| 51 Norris Geyser Basin, Wyo | 2276 | +0.021 | −0.059 | −0.104 | −0.038 | −0.083 |
| 52 Lower Geyser Basin, Wyo | 2200 | −0.001 | −0.058 | −0.103 | −0.059 | −0.104 |
| 55 Mt. Hamilton, Cal | 1282 | −0.003 | −0.014 | −0.017 | −0.017 | −0.020 |
| 63 El Paso, Tex | 1146 | +0.007 | −0.030 | −0.054 | −0.023 | −0.047 |
| 64 Nogales, Ariz | 1181 | −0.050 | −0.029 | −0.046 | −0.079 | −0.096 |
| 67 Goldfield, Nev | 1716 | −0.013 | −0.043 | −0.074 | −0.056 | −0.087 |
| 68 Yavapai, Ariz | 2179 | +0.001 | −0.045 | −0.080 | −0.044 | −0.079 |
| 70 Gallup, N. Mex | 1990 | −0.013 | −0.053 | −0.095 | −0.066 | −0.108 |
| 71 Las Vegas, N. Mex | 1960 | +0.003 | −0.053 | −0.094 | −0.050 | −0.091 |
| 75 Lead, S. Dak | 1590 | +0.052 | −0.038 | −0.064 | +0.014 | −0.012 |
| 81 Sisson, Cal | 1048 | −0.010 | −0.033 | −0.058 | −0.043 | −0.068 |
| 82 Rock Springs, Wyo | 1910 | +0.013 | −0.052 | −0.093 | −0.039 | −0.080 |
| 98 Alpine, Tex | 1359 | +0.021 | −0.034 | −0.061 | −0.013 | −0.040 |
| 99 Farwell, Tex | 1259 | −0.016 | −0.030 | −0.055 | −0.046 | −0.071 |
| 102 Cloudland, Tenn | 1890 | +0.004 | −0.025 | −0.039 | −0.021 | −0.035 |
| 109 Sheridan, Wyo | 1150 | +0.032 | −0.032 | −0.068 | 0.000 | −0.036 |
| 110 Boulder, Mont | 1493 | −0.015 | −0.046 | −0.077 | −0.061 | −0.092 |
| 114 Truckee, Cal | 1805 | −0.028 | −0.051 | −0.085 | −0.079 | −0.113 |
| 115 Winnemucca, Nev | 1311 | −0.009 | −0.032 | −0.062 | −0.041 | −0.071 |
| 116 Ely, Nev | 1962 | −0.021 | −0.055 | −0.094 | −0.076 | −0.115 |
| 117 Guernsey, Wyo | 1322 | +0.036 | −0.031 | −0.062 | +0.005 | −0.026 |
| 195 Lander, Wyo | 1635 | +0.019 | −0.047 | −0.090 | −0.028 | −0.071 |
| 198 Edgemont, S. Dak | 1066 | +0.054 | −0.028 | −0.052 | +0.026 | +0.002 |
| 202 Moorecroft, Wyo | 1295 | +0.021 | −0.031 | −0.058 | −0.010 | −0.037 |
| 269 Hill City, S. Dak | 1518 | +0.042 | −0.040 | −0.067 | +0.002 | −0.025 |
| 270 Newcastle, Wyo | 1328 | +0.029 | −0.035 | −0.064 | −0.006 | −0.035 |
| 271 Bridgeport, Neb | 1114 | −0.008 | −0.029 | −0.053 | −0.037 | −0.061 |
| 272 Buford, Wyo | 2396 | +0.046 | −0.057 | −0.100 | −0.011 | −0.054 |
| 273 Boulder, Colo | 1630 | −0.014 | −0.048 | −0.092 | −0.062 | −0.106 |
| 274 Lafayette, Colo | 1595 | −0.020 | −0.040 | −0.081 | −0.060 | −0.101 |
| 275 Brighton, Colo | 1511 | −0.006 | −0.038 | −0.073 | −0.044 | −0.079 |
| 276 Idaho Springs, Colo | 2303 | +0.022 | −0.068 | −0.120 | −0.046 | −0.098 |
| Mean with regard to sign | | +0.005 | 0.043 | 0.077 | −0.037 | −0.072 |
| Mean without regard to sign | | 0.019 | | | 0.040 | 0.072 |

Further evidence regarding the isostatic condition of the earth's crust is given in Table 3[4] which shows the effect on gravity anomalies of not taking into account the negative attraction of the compensation of the topography within certain distances of 42 stations. Each station used in the test has an elevation of more than 3000 feet. It is evident that the anomaly will be affected in proportion to the average thickness of the disc of topography whose compensation is ignored. Thus for an average elevation of 6000 feet the change in the anomaly will be one half that of 3000 feet. The elevations of the stations given in the table do not represent the average elevation of the surface forms considered. Some stations are on a peak or ridge above the general level, whereas others are in valleys below the average elevation of the surrounding region.

Let the ordinary method of compensation whose anomalies are shown in column 3 be called A; the one in which compensation is ignored for topography out to 17.9 miles, anomalies for which are in column 6, be called B; and the third method, the anomalies of which are shown in column 7 be called C. A careful inspection of the table shows that the A anomalies are, in nearly all cases, smaller than those for either the B or C methods.

The smallness of the A, as compared with the B and C anomalies, is shown best as tabulated below.

TABLE 4.—ANOMALIES WITHOUT REGARD TO SIGN

| LIMITS | | NUMBER BY | | |
|---|---|---|---|---|
| | | Method A | Method B | Method C |
| *dyne* | *dyne* | | | |
| 0.000 | 0.009 | 12 | 4 | 1 |
| 0.010 | 0.019 | 11 | 6 | 1 |
| 0.020 | 0.029 | 12 | 4 | 3 |
| 0.030 | 0.039 | 2 | 5 | 4 |
| 0.040 | 0.049 | 2 | 8 | 2 |
| 0.050 | 0.059 | 3 | 6 | 3 |
| 0.060 | 0.069 | 0 | 6 | 4 |
| 0.070 | 0.079 | 0 | 3 | 5 |
| 0.080 | 0.089 | 0 | 0 | 3 |
| 0.090 | 0.099 | 0 | 0 | 7 |
| 0.100 | 0.109 | 0 | 0 | 6 |
| 0.110 | 0.119 | 0 | 0 | 3 |

If the sign of the anomalies is considered, it is found that for A, 22 are positive and 20 negative; for B, 4 are positive and 37 negative; while for C, only 1 is positive and 41 are negative.

[4] Copied from Proc. Nat. Acad. Sci. 7: 24. 1921.

If, for a large area, a gravity anomaly map were constructed, similar to illustration No. 11 of Special Publication No. 40 of the Coast and Geodetic Survey, it would be found that the high ground would be distinctly indicated on the B and C anomaly maps, while for the A map the high ground bears no relation to the anomaly contours.

If it is agreed that the method employed in gravity reductions which most uniformly reduces or eliminates the anomalies is the most probable, we must conclude that the A method is better than either the B or C method. A disc of topography 3000 feet in thickness and 18 miles in radius does not escape compensation to a marked degree. This conclusion seems to be inevitable, for not only is there the evidence from gravity anomalies, but topography in the form of masses above sea level is caused by the process or processes which change the density in the earth's crust below. As the larger surface features are caused by what we have been accustomed to call the compensation, instead of the compensation being caused in some way by the surface features, it is reasonable to believe that there is not much more topography than there is compensation.

If the crust under any area were in equilibrium before uplift, and if uplift is due to expansion and change in volume without any change in mass, the portion of the crust in question should still be in equilibrium. At least it would not be heavier than normal. But after uplift there is erosion acting as an active agent in removing material. If the earth's crust were sufficiently strong it would resist the tendency for the crust under the eroded area to move upward under gravitational forces. Gravity anomalies at stations in areas of erosion indicate that the crust below is in equilibrium, and the inference is that the material of the crust has been moved upward by the nucleal material which has been forced under it to restore the equilibrium.

The gravity anomalies and abstract reasoning both favor the idea that even masses of moderate size above sea level are not extra loads on the crust. The anomalies do not enable us to know whether the compensation is directly under a topographic feature or distributed in the crust at some distance horizontally from the column directly below the feature.

That the earth's crust has ability to resist certain stress differences is beyond question. There are stress differences in the crust between high areas and adjacent lower ones. The fact that areas have been high ones for long periods of time proves that the material of the crust is sufficiently strong to prevent a column of small cross-section being in isostatic equilibrium independent of the small columns surrounding

it. Should a peak such as Mt. Shasta, with a base of small area, lose material by erosion more rapidly than the areas of lower elevation surrounding it, surely the column under Shasta about 60 miles in length would not be pushed up by the isostatic adjustment more rapidly than the small columns adjacent to it. If the crustal material were so weak as to permit this, then surely the base of Shasta would collapse and push out under the surrounding area resulting in a more uniform elevation of the surface of the whole region. The area under and around Shasta must be what may be termed an isostatic unit. The test described in the first pages of this paper gives some idea of the maximum horizontal dimensions of this unit.

When a major uplift takes place by thermal and other type or types of expansion, in an area presumably in equilibrium, there will be much resistance to be overcome. The unaffected crust to the sides of the expanding material tends to resist free movement. Presumably the greatest expansion will occur in that portion of the crust which is overlaid by the deepest sedimentary beds, and the least expansion should be under the thinnest sediments. The expansions of different portions of the material should progress at different rates and even at different times.

The expansion of any small unit of the crust tends to be in all directions, but there is very strong resistance to movement downward and to the sides, and the general direction of least resistance will be upward. But the upward resistance will vary from place to place. When a large amount of material has been forced up directly over a very active region, the gravitational resistance to further uplift may be greater than the resistance of the material surrounding it. Further uplift would occur along inclined directions, and some of the topography formed by the expanding material would not be directly above the latter. Here there would be regional rather than local distribution of the compensation. Strictly, we should say we would have regional rather than local distribution of the topography, since the change in density (called compensation) is the cause of the masses (topography) above the plane of reference which is sea level. In the case of original uplift the isostatic unit appears to be larger in cross-section than that of the column of the crust directly under the uplifted feature.

The computations of the effect of the topography and of the isosatic compensation on the value of gravity are made for small areas and columns, but this is done to facilitate the work. This method does not in any way detract from the reliability of the gravity anom-

alies obtained. The values of the anomalies would be the same within several units if the compensation were made for any other horizontal distribution out to a moderate distance from the topographic features.

The writer and many other students of the earth's crust believe the theory of isostasy is substantially true. The major uplift at least must then be due to expansion and increase in volume of the crust beneath the affected area, and the isostatic adjustment or movement of matter to restore equilibrium as erosion and sedimentation occur must be below rather than within the crust.

We do not know the method of distribution of the compensation vertically, nor do we know the depth of compensation, for this is a function of the vertical distribution. We do know that, in order to eliminate gravity anomalies to the extent to which uniform vertical distribution does, the center of gravity of the compensation must be between 30 and 50 kilometers below the surface.

We are able to account for many of the larger gravity anomalies by the presence of abnormally light or heavy material near the gravity stations. This is especially true of those stations over large masses of pre-Cambrian and Cenozoic material. The stations on Puget Sound and on and near the Black Hills in South Dakota are notable examples. In consequence of being able thus to account for most of the large anomalies,[5] we are justified in claiming a more perfect equilibrium of the earth's crust than would have been justified several years back when the anomalies were supposed to have been due largely to lack of equilibrium.

It appears to be reasonably certain that a mass of the crust 3000 feet or more in thickness, with a radius of 18 miles is largely compensated. We do not know the cross-section of the isostatic unit of the earth's crust, although the tests with gravity anomalies indicate it to be probably less than 100 miles in radius. The configuration of the earth's surface in a mountain area is a function of the chemical compostition of the crustal material below, the manner in which sediments were laid down before the uplift began, the expansion of the crustal material, and the distribution of resistances to resulting upward movement, to the irregular erosion of the uplifted area, and to the distribution of resistances to the upward movement of crustal material as nucleal material is forced below the crust to balance the effect of erosion.

All of the problems outlined above are important ones, but not the least important is the determination of the cross-section of

[5] In U. S. Coast and Geodetic Survey, Special Publication No. 40, 1917, this explanation of large gravity anomalies is outlined for the first time.

the isostatic unit. It is not very small nor is it very large. The writer feels that it is from 25 to 50 miles in radius. It is believed that much may be learned on this matter by the combined efforts of the geologists, geophysicist, geochemist, and the geodesist.

MINERALOGY.—*Chlorophoenicite, a new mineral from Franklin Furnace, New Jersey*[1] (Preliminary description). WILLIAM F. FOSHAG, National Museum and R. B. GAGE, Trenton, New Jersey.

The material herein described was collected by one of us (R. B. G.) at Franklin Furnace, New Jersey during the year 1923. Upon examination, it proved to be a new species, and the name chlorophoenicite[2] (χλωρος = green, φοινικος = purple red), in allusion to the property it possesses of changing from green in natural light to a light purplish red in artificial light, is here given it.

Chlorophoenicite is a hydroxyarsenate of manganese and zinc carrying minor percentages of lime and magnesia. Pure, homogeneous material yielded the following analysis:

TABLE 1.—COMPOSITION OF CHLOROPHOENICITE

| | ACTUAL ANALYSIS | THEORETICAL |
|---|---|---|
| $H_2O$ | 11.60 | 11.4 |
| CaO | 3.36 | |
| MgO | 1.34 | |
| FeO | 0.48 | |
| MnO | 34.46 | 38.5 |
| ZnO | 29.72 | 29.3 |
| $As_2O_5$ | 19.24 | 20.8 |
| Total | 100.24 | 100.0 |

This analysis leads to the formula $10\ RO \cdot As_2O_5 \cdot 7H_2O$ and a ratio of Mn to Zn of approximately 6:4. This may also be written $R_3As_2O_8 \cdot 7R(OH)_2$, a composition remarkable in its low ratio of arsenate to hydroxide. The theoretical composition of this compound with a ratio of Mn:Zn of 6:4 is given in Table 1.

When heated in the closed tube, these crystals give off water at a fairly low temperature, retain their shape, become black in color with a highly brilliant luster. The surface of the tube is not coated or colored by any arsenic coating.

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] The writers are indebted to Dr. H. S. Washington for suggesting this name.

Under the blow pipe, the crystals darken instantly, but only fuse with difficulty on the edges. They do not decrepitate or exfoliate. The brilliant luster shown in the closed tube is destroyed and the faces of the crystal become rough and porous. These tests easily distinguish these crystals from green willemite crystals of a similar shape and color which do not darken in a closed tube and fuse fairly easily in a blow pipe flame.

The chlorophoenicite forms long prismatic crystals ranging in size up to 8 mm. The crystal system is monoclinic and the crystals, elongated in the direction of the b axis, have a habit similar to epidote. The crystals are deeply striated parallel to the b axis and the small prism faces are rounded and usually etched. The color is a light grayish green in natural light but is pink or light purplish red in artificial light. This difference in color is more pronounced on the prism faces than on the pinacoids. The plane of the optic axes is across the prisms. 2V is large with a dispersion of $\rho > \upsilon$ and strong; the indices of refraction are, $\alpha = 1.682$, $\beta = 1.690$ $\gamma = 1.697$.

Chlorophoenicite occurs in cracks and crevices in the typical franklinite-zincite are of Franklin Furnace, New Jersey. It is associated with small rose red crystals of leucophoenicite, brown tephroite and calcite. The chlorophoenicite itself is very similar in appearance to the light green willemite that is found in some of the crevices and might at first glance be mistaken for it.

BOTANY.—*A new genus of Leguminosae.* CHARLES V. PIPER, Bureau of Plant Industry.

A Costa Rican climbing shrub or liana collected 25 years ago by Tonduz seems clearly to represent an undescribed genus related to *Calopogonium* Desvaux. The large leaflets, closely resembling the leaves of the aspen, and the dense racemes of very small pubescent yellowish flowers are conspicuous characters.

**Leycephyllum** Piper, gen. nov.

Climbing shrub; leaves trifoliolate, the leaflets entire; stipules striate; flowers small, yellowish, numerous, in racemes from the axils of the upper leaves; calyx campanulate, the upper lip short bidentate, the lower lip 3-toothed, the median one as long as the calyx-tube, the lateral ones short; standard obovate, stipitate, the upper margin incurved or hooded, the base without callosities or auricles, but the basal margins thickened; wing oblong, stipitate, the auricle somewhat hook-like; keel oblong-obovate, stipitate, not auricled; vexillar stamen free, its filament enlarged at base, the other stamens united below, free above the middle; anthers oval; style curved, glabrous; stigma terminal, very oblique, minute; ovary pubescent.

**Leycephyllum micranthum** Piper, sp. nov.

Stems terete, densely puberulent when young, becoming glabrous; stipules lanceolate, striate, puberulent, 3 to 4 mm. long; petioles terete, channelled above, faintly striate-ridged, puberulent, usually longer than the leaflets; stipels apparently wanting; petiolules very pubescent; leaflets entire, firm membranaceous, broadly ovate to suborbicular, 3-nerved from the base, strongly acuminate and short-apiculate, broadly cuneate to rounded or even subcordate at base, sparsely puberulent above especially on the nerves, less so beneath, 8 to 10 cm. long; peduncles densely brown puberulent, floriferous from near the base, knotted with the pedicellar glands, 5 to 6 cm. long including the racemes of numerous flowers; bracts lanceolate, 3 mm. long, narrowed at base, long attenuate to apex, densely puberulent, much longer than the buds; pedicels shorter than the calyx; calyx densely brown puberulent, the tube 1.5 mm. long, the median lower tooth as long; corolla yellowish; standard 5 mm. long, puberulent on the outer side and densely covered near the tip with minute sessile glands; wings oblong, 5 mm., the auricle hook-like; keel as long as the wings, oblong-obovate, stipitate.

Type in the U. S. National Herbarium, no. 938783, collected at Las Vueltas, Tucurrique, Costa Rica, 635 meters altitude, January, 1899, by Adolpho Tonduz (no. 12951). The label notes "liane a tige aplatir; fl. jaunatres; fr. rouge et noir."

BOTANY.—Aciachne, *a cleistogamous grass of the high Andes.* AGNES CHASE, Department of Agriculture.

The genus *Aciachne* was described[1] by Bentham as dioecious, "Spiculae unisexuales, ♂ ignotae." There is one species, *A. pulvinata* Benth., "Andes of South America." Of the seven collections cited two, *Lechler* 1813 and *Mandon* 1287, are represented in the U. S. National Herbarium. Bentham states: "Notwithstanding the number of specimens from most of the above localities, I have been unable to detect any but female spikelets, which on some of them are numerous, often past flower, and showing only the persistent outer glumes. The males are probably on distinct plants and most likely with a different inflorescence, rendering it difficult to identify them. If that be the case, it is possible that the male of this, or an allied species may be represented by Lechler's specimens gathered at Gachapata in Peru a month earlier than the females above referred to, and distributed with the number 599. In these the leaves are longer, all erect, and very rigid,

*Aciachne pulvinata.* Fig. 1, spikelet × 10; fig. 2, floret × 10; fig. 3, palea × 10; fig. 4, caryopsis crowned by old stigmas and stamens × 20.

[1] Hook. Icon. Pl. **4**: 44. *pl.* 1362. 1881.

1 to 3 in. long. The spikelets are several in a loose, slightly branched, rigid, erect panicle of 1 to 2 inches, the glumes precisely like those of the females, but enclosing three perfect stamens and the ovary reduced to an ovoid rudiment with two small points." The plate shows a flower with ovary and stigmas.

In the Genera Plantarum[2] "Spiculae unisexuales ♂ ignotae" is repeated. Hackel says[3] of *Aciachne* "♂ Ae. unbekannt."

Practically all the numerous specimens of this grass preserved in herbaria have well-developed fruit. Professor A. S. Hitchcock, in a letter from Lima, Peru, writes, "A peculiar and wonderful grass is *Aciachne*. This in some places is the dominant or even the only grass on whole hills. It is not eaten by stock. It occurs in little mounds or patches, a deep green, dying out in the center and forming fairy rings. It is commonly supposed by the people there to be a moss. The spikelets are hidden among the short prickly leaves but the little sharp-pointed fruits rattle out easily and stick in the clothing."

The fact that the plant fruits so abundantly suggested that the mystery of the staminate form might be explained by cleistogamy. Professor Hitchcock's collections contained an abundance of fruiting material. A floret boiled in glycerine and water and carefully opened disclosed two empty anthers crushed with the old stigma at the summit of the caryopsis. The anthers are nearly 1 mm. long, larger than the anthers found in some cleistogenes. All florets opened contained anthers, some two, some three. Figure 4 shows the caryopsis with stigmas and anthers as they appear (slightly loosened by needles) taken from a boiled floret. In most cases the mass of crushed stigmas and anthers fell as the caryopsis was removed, but dissection showed 2 or 3 anthers in every case. The filaments were very short, in some cases none were found. The anthers must be nearly sessile, torn loose and carried upward by the developing fertilized ovary, and finally crushed with the old stigmas against the roof of the tiny chamber within the indurate lemma.

Bentham figures a large truncate palea and a pair of long lodicules. My dissections reveal a small hyaline deeply 2-lobed palea (figure 3) and only rudimentary lodicules. The lemma is very difficult to open and can not be spread out without cutting off the acuminate summit; even then it cracks lengthwise. It seems probable that among the dissections of several florets under the microscope Bentham

[2] Benth. & Hook. Gen. Pl. **3**: 1143. 1883.
[3] Engler & Prantl, *Pflanzenreich* 2[2]: 47. 1887.

found a part of a lemma from which the summit had been cut and mistook it for a palea, while the true palea split to the base in dissection was mistaken for lodicules.

We have not seen Lechler's no. 599, referred to by Bentham as possibly the staminate form of *Aciachne*. Growing with *Aciachne* at Cerro de Pasco, Peru, Professor Hitchcock found over-mature plants of *Dissanthelium calycinum* (Presl) Hitchc., which agree fairly well with Bentham's observations on Lechler's no. 599 and would appear to be the same species, though the glumes are abruptly pointed, not obtuse as in *Aciachne*.

Baillon in a note[4] on the 1-flowered inflorescence of *Aciachne* refers to it as "polygame-dioique." His description of palea and lodicules ("glumelle interieure" and "glumellules") seems to be drawn from Bentham's illustration, but he found three stamens and an ovary with plumose styles, evidently in a young spikelet. He also observes a caryopsis but does not mention the included stamens. Pilger mentions[5] *Aciachne* in a paper on monoecious and dioecious grasses.

ZOOLOGY.—*Snails of the genus* Succinea *from the Maritime Province of Sibera.* T. D. A. COCKERELL, University of Colorado. (Communicated by PAUL BARTSCH).

Dr. Leopold v. Schrenck, in his account of the mollusca of the Amur region of Siberia,[1] listed ostensibly one species of *Succinea*, namely *S. putris* Linnaeus. However, he divided this into forma *ventricosior* (*S. amphibia* Draparnaud) and forma *gracilior* (*S. pfeifferi* Rossmaessler), and if his identifications were correct, he had not only two species but two subgenera. Westerlund described two varieties of *S. putris* from Siberia, namely variety *firma* Westerlund, above whitish, beneath amber-color, whorls 4, length 16-17 mm., width 9-10 mm. (Ins. Briakowskij, n. lat 70°, 39′), and variety *hazayana* Westerlund, red yellow, whorls 4-4.5, length 19.5-22 mm., width 9-10 mm. (Tunguska N. lat. 61°). *Succinea oblonga* var. *agonostoma* Kuester is said by Westerlund to occur in Germany, Sweden, and Siberia. The variety *elongata* Westerlund is synonymous with it. *Succinea chrysis* Westerlund is found, accord-

[4] Bull. Soc. Linn. Paris **2**: 1034. 1892

[5] Bot. Jahrb. Engler **34**: 386. 1904.

[1] *Reisen und Forchungen im Amurlande in den Jahren 1854-1856.* St. Petersburg, 1859-1867.

ing to Dall,[2] from Greenland to Bering Strait and on the opposite (Asiatic) shore of the Strait.

The division of *Succinea* into subgenera has led to differences of opinion, and has perhaps been overdone, as Dall has suggested. Nevertheless, there are certainly two groups among the commoner Palearctic and Nearctic species, namely *Succinea* Draparnaud, proper (type *S. putris*), and *Amphibina* Hartmann (type *S. pfeifferi*). Not only do these differ in the appearance of the shell, but *Succinea* proper has the jaw ribbed, which is not the case in *Amphibina*. The two types of jaw are well illustrated by W. G. Binney[3] (*S. totteniana* Morse and *S. avara* Say) and by Moquin-Tandon.[4] *Lucena* Oken, originally based on *S. putris*, is *Succinea* proper as here understood. *Oxyloma* Westerlund, containing *S. dunkeri* Zelebor from Dobrudscha and *S. hungarica* Hazay from Hungary, is probably not to be separated from *Amphibina*. Both these species are so close to *S. elegans* Risso, which belongs to *Amphibina*, that good authorities have regarded them as subspecies of it.

In the Maritime Province of Siberia, during the summer of 1923, I found two kinds of *Succinea*, both of the typical subgenus, and closely related to *S. putris*. When I collected them, as they climbed the damp herbage during wet weather, they struck me as being decidedly different from *S. putris*, a species very familiar to me in England. Even in England, however, *S. putris* is variable, and from various parts of Europe numerous varieties have been described by Moquin-Tandon, Hazay, Baudon, Clessin, Colbeau, Bourguignat, Picard, Paulucci, Westerlund, and Pascal. Since there is so much similiarity in the shells of related forms of *Succinea*, it is quite possible that anatomical studies will show several of these "varieties" to be distinct species, but others are certainly phases without even racial significance. Germain[5] does not hesitate to treat *S. charpentieri* Dumont and Mortillet and *S. milneedwardsi* Bourguignat, regarded as mere varieties of *S. putris* by Westerlund, as perfectly distinct species. Owing to the uncertainty surrounding the whole subject, I present the Siberian forms as subspecies of *S. putris*, a course which at any rate calls attention to their obvious affinities. Should they hereafter be separated specifically, they will probably rank as forms of a single species, yet racially distinct, as the characters were quite uniform (except for the usual individual variation in shape) in each locality.

[2] Alaska (Harriman Expedition) **13**: 59. 1905.
[3] *The terrestrial air-breathing mollusks of the United States* **5**: 415. 1878.
[4] Hist. Nat. Mollusq. Ter. & Fluv. France **3**: *pl.* 7. 1855.
[5] Mollusques de la France **2**: 225. 1913.

**Succinea putris olgae,** new subspecies.

Shell 19 to 21.6 mm. long, 11 to 11.7 mm. wide; aperture 14 to 16 mm. long, 9.5 mm. wide; general form of *S. putris*, size like variety *hazayana* Westerlund, but broader and much paler, dullish pale horn color, with moderate spire. Jaw about as wide as long (1.7 mm)., ferruginous, the accessory plate usually longer than broad, thus longer in proportion to its width than in *S. putris*; ends (lateral lobes) distinctly broader than in *S. putris*; ribs low and broad, three or five; median inferior projection well developed. Lingual membrane with the teeth (centrals and laterals) only about half as long as the basal plate, the mesocone broad and very obtuse, the ectocones poorly developed; marginals dagger-shaped, curved, with a single rudimentary ectocone.

Olga, Siberia, July 13, on hill above the village (type locality); also (immature specimens) near the Kudia River, July. This is doubtless the shell which A. Adams reported as *S. putris* from Olga Bay and Vladimir Bay. *Type.*—Cat. No. 360790 U. S. N. M.

**Succinea putris mera,** new subspecies.

Shell 20 mm. long, 11.7 wide; aperture 16 mm. long, nearly 9 wide; general form of a very broad *S. putris*, but very thin, strongly reddish moderately shining. Jaw as in the last, except that the accessory plate is broader; lingual membrane as in the last. Animal in life very pale translucent yellowish; tentacles grey above, abruptly contracted near end.

Okeanskaja, Siberia, July and August, abundant close to the railway station. *Type.*—Cat. No. 360791 U. S. N. M.

The substantial identity in jaw and lingual membrane indicates that these forms, although locally constant in their color-differences, are conspecific. *Succinea lauta* Gould was identified by A. Adams in his collections from Vladimir Bay. *Succinea lauta* was described by Gould as found on shrubbery at Hakodate, which is in northern Japan nearly opposite Vladivostok. It was said to be a very large, thin shell, most like *S. obliqua* Say. Dr. Bartsch has kindly sent me a specimen, and it is certainly another member of the *S. putris* group, differing very little from typical *S. putris* as figured by Moquin-Tandon and Baudon. The longer spire and generally more fusiform shape distinguish it from the above-described Siberian shells, but whether it agrees with them in dental and jaw characters remains to be determined. The Japanese *S. horticola* Reinhardt, from Matsuyama, also sent by Dr. Bartsch, is an entirely different shell, apparently referable to *Amphibina*, although Pilsbry seems to think otherwise. The Japanese *S. hirasei* Pilsbry is an *Amphibina*. I do not believe any of these Japanese species occur in Siberia. The record of Adams may be safely set aside, as it has been shown in several other cases that he made serious errors in locality or identity.

*Succinea ogasawarae* Pilsbry and *S. punctulispira* Pilsbry, from the Bonin Islands, are much smaller than my Siberian shells; the former is a curious shell, with the spire reduced to a mere papilla. The Chinese *S. chinensis* Pfeiffer and *S. gimlettei* Jones and Preston are less than 10 mm. long, and appear to belong to *Amphibina*.

The American forms most nearly allied to *S. putris*, namely *S. ovalis* Say (*obliqua* Say) and *S. totteniana* Morse (now usually considered a race or variety of *ovalis*), differ conspicuously from my Siberian species in the jaw, which has no salient median inferior projection, and equally in the teeth, the pointed mesocones being much longer, while the marginals have two little cusps. There is thus no possibility of specific identity.

A remarkable thing about the genus *Succinea* is the presence of species on remote islands, such as the Hawaiian Islands (numerous species), Galapagos Islands Cocos Island, Clarion Island, Sokotra, etc. Darwin thought that the young might be carried on the feet of birds. Lyell thought that the eggs might be carried among the feathers of water-fowl.

ENTOMOLOGY.—*Notes on* Grylloblatta *with description of a new species.* A. N. CAUDELL, National Museum.

The examination of additional specimens of the *Grylloblatta* found in California, as recently announced[1] by the writer and of a topotypic nymph of the Canadian species *campodeiformis* Walker, makes it advisable to describe the specimens from California as belonging to a distinct species. Dr. E. M. Walker has kindly examined the holotype of the Californian form and pronounces it unquestionably distinct from the Canadian species. It is therefore here described as:

**Grylloblatta barberi,** new species.

The type of this species is the large male nymph discussed in the aforementioned article. In general appearance it is very like the Canadian *campodeiformis* but structurally it differs from that species as follows: The antennae are composed of a greater number of segments, their number ranging from 35 to 40 while the maximum number noted in the related species is 29 in the adult, a nymph of that form before the writer having 25. The antennae are also decidedly longer than in the Canadian form, as shown by measurements given below. The posterior femora are, as noted in the previous article, longer than in *campodeiformis*, the appended comparative measurements being illustrative. The transverse sulcus near the anterior margin of the pronotal disk is sinuate in all specimens seen while in *campodeiformis* it is straight as shown by Walker's description and illustrated in the immature specimen of that species examined. Thus the characters mentioned as differential in the former article appear to be constant and specific except for the fact that the posterior margin of the pronotal disk is obtuse-angulate in the nymphs of both species, thus being a nymphal character. The cerci are more tapering and considerably longer than in *campodeiformis* and the large nymph selected as holotype, which is very probably in the last

[1] Can. Ent. **55**: 148–150. 1923.

nymphal instar, has the same number of segments as described for adults of the Canadian form; in the earlier stages, however, only seven segments are present. The smaller female nymphs have the inner valves of the ovipositor arising caudad of the ventral ones and scarcely exceeding the tips of the latter.

The following measurements are from the four immature specmens forming the basis of the present description, from a single immature topotypic female of *campodeiformis* and from measurements given in Dr. Walker's published articles, or inferred therefrom.

| | | TOTAL LENGTH TO TIP OF ABDOMEN | ANTENNAE | PRONOTUM | POSTERIOR FEMORA | CERCUS | NUMBER OF SEGMENTS IN THE ANTENNAE | NUMBER OF SEGMENTS IN THE CERCUS |
|---|---|---|---|---|---|---|---|---|
| | | mm. | mm. | mm. | | mm. | | |
| *Grylloblatta barberi* n. sp. | Holotype ♂ nymph. | 20 | 15 | 3 | 5 | 6 | 40 and ? | 8 |
| | Paratype A. ♂ nymph. | 19 | 14 | 2.8 | 4.5 | 5.8 | 39 and ? | 8 |
| | Paratype B. ♀ nymph. | 17 | 11 | 2.5 | 4 | 5 | 35 and ? | 7 |
| | Paratype C. ♀ nymph. | 18 | ? | ? | 4 | 4.25 | 36 and 38 | 7 |
| *Grylloblatta campodeiformis* Walker. | Type, adult ♀. | 30 | 8.5 | ? | 3.4 | 3.6 | 26 to 29 | 8 |
| | Cotype, adult ♀. | 30 | 9 | ? | 3.2 | 3.5 | 26 to 29 | 8 |
| | Topotype, adult ♂. | 16.5 | ? | ? | ? | ? | ? ? | 8 |
| | Topotype, ♀ nymph. | 15 | ? | ? | 3.25 | ? | ? ? | 8 |
| | *Topotype, ♀ nymph. | 13 | 7 | 2 | 2.5 | 3.5 | 25 and 25 | 7 |
| | Topotype, ♂ nymph. | 11 | ? | ? | 2.75 | ? | 22 and ? | 8 |
| | Topotype, ♂ nymph. | 11 | ? | ? | 2.1 | ? | ? ? | 8 |
| | Topotype, ♂ nymph. | 12.5 | ? | ? | 3.1 | ? | ? ? | 8 |

*Specimen examined by the writer and now in the National Museum.

The type material of *barberi* consists of four specimens as follows: Holotype, the large male nymph, evidently in the last instar, taken by H. S. Barber on January 23, 1923, in Plumas County, California and discussed in the previous paper by the present writer;[2] paratype A, an immature male, also probably in the last instar, taken at the same locality as the holotype by F. J. Silor; paratype B, an immature female specimen of an earlier instar than the above but with the same data; paratype C, with same data as the last and evidently in the same stage of development.

Holotype and paratypes A and B in the collection of the United States National Museum; paratype C sent in exchange to Dr. E. M. Walker.

Cat. no. 27265 U. S. N. M.

The writer takes pleasure in dedicating this interesting species to Herbert S. Barber of the National Museum in recognition of his ability to discover interesting and unusual forms of insect life in unsuspected places.

[2] See footnote 1.

## NOTES

The paratypes of *Grylloblatta barberi* were taken by Mr. Silor some five hundred feet above the point where Mr. Barber collected the holotype, one being found in an outhouse and the others under pieces of timber. Mr. Silor writes that if they are exposed by turning over the timber on a hot day and the sun hits them, they move slowly, but if they are found on a cloudy day they run rapidly. Dr. Walker writes that living specimens of *Grylloblatta campodeiformis* observed by him ran about like cockroaches, and would eat nothing but cake; Mr. Hearle found, however, that they would feed readily on flies with the wings removed, and Dr. C. G. Hewitt fed specimens on ant pupae.

The antennae of *Gryloblatta* bear sensory pits, small circular scars present on all segments except the apical one. There are several on each segment forming a preapical circle around each segment except the basal one, where they are apparently absent on the dorsal surface. From each of these scars or pits arises a very long and slender tactile hair, longer than the setae and finer than the ordinary hairs. These organs are present in both species of *Grylloblatta* and also in the Asiatic *Galloisiana nipponensis* of Caudell and King, though in the latter species they are less obvious.

Both species of *Grylloblatta* and *Galloisiana nipponensis* possess an invaginated gland which opens between the first and second ventral abdominal segments. Normally this gland is noticeable only as a pair of transverse, closely appressed lips, but in two of the immature specimens of *Grylloblatta barberi* a soft, white, tongue-like process is protruded; in the larger nymph this process is about three-fourths of one millimeter in length and about one-fourth as thick as long. This gland is present in both sexes and in a single immature specimen of *Grylloblatta campodeiformis* studied by the writer it is partly protruded and the apex appears truncate and slightly chitinized, an appearance not noticed in *barberi*. On the posterior margin of the basal segment of the abdomen, just above this gland, there is a pair of small setae. In *Galloisiana nipponensis* this gland is obscurely indicated in the two alcoholic nymph studied, being not at all extruded; the only adult specimen of that species seen has the venter mostly eaten away by ants. The glandular structure discussed above can not be satisfactorily investigated without dissection, and limited material makes this inadvisable.

Dr. Walker in his description of the nymphs of *Grylloblatta campodeiformis* notes that the cerci consist of eight segments, the same as in the adult, but with the basal two segments less distinctly separated. This is not true, however, of a topotypic nymph of that species examined by the present writer, as in this specimen the cerci are but seven segmented, and the basal one of these seven segments is so closely amalgamated with the succeeding one as to be recognized as distinct only by setal arrangement and the position of sensory pits.

MAMMALOGY.—*Two new kangaroo rats from Arizona.* E. A. GOLDMAN, Biological Survey.

Among the results of recent field work in northern Arizona have been the discovery of two undescribed kangaroo rats of the genus *Dipodomys*. These are characterized as follows:

**Dipodomys microps celsus,** subsp. nov.

Virgin Valley Kangaroo Rat.

*Type* from 6 miles north of Wolf Hole, Arizona (altitude 3,500 feet). No. 243101, ♂ adult, U. S. National Museum (Biological Survey Collection)' collected by E. A. Goldman, October 16, 1922. Original number 23411.

*General characters.*—Closely allied to *Dipodomys microps levipes,* but size usually larger and color slightly darker, the back more obscured by dusky hairs; skull differing most noticeably in larger size of mastoid bullae; hind foot with five toes as usual in the species. Decidedly larger than *D. m. microps* and differing otherwise as from *D. m. levipes.*

*Color.*—*Type* (fresh pelage): Upper parts in general near pinkish buff, moderately mixed with black, the buffy element purest and most intense along sides of body, becoming lighter buffy on head and face; under parts, postauricular spots, fore limbs, hind feet above, usual hip stripes, and tail at extreme base all around pure white; tail beyond extreme base blackish along upper and lower median stripes to near tip where the lengthening hairs become dusky all around, the sides white to subterminal area mentioned; pencilled tip of tail inconspicuously dusky; the dark points of hairs only partially concealing the white under color; hind legs immediately above ankles blackish, except a white line along inner side; soles of hind feet black to toes, which are white; usual dark facial markings broad and distinct.

*Skull.*—Similar to that of *D. m. levipes,* but broader, more massive; mastoid bullae decidedly larger; maxillary arches slightly broader; dentition about the same. Compared with that of *D. m. microps* the skull is decidedly larger and differs in other respects as from that of *D. m. levipes.*

*Measurements.—Type:* Total length, 284; tail vertebrae, 170; hind foot, 44. Average and extremes of 10 adults, including type, from type locality: 285.6 (277–298); 171.3 (164–182); 43.4 (42.5–44). *Skull* (type): Greatest length on median line, 36; greatest breadth (between outer sides of audital bullae), 25.3, breadth across maxillary arches, 20; least width of suproccipital (near interparietal), 1.2; maxillary toothrow, 5.

*Remarks.*—While closely allied to the widely ranging subspecies *D. m. levipes,* this kangaroo rat is readily distinguished by the cranial characters indicated. Its geographic range appears to be the upper part of the Virgin River Valley and adjacent parts of the plateau region in Utah and Arizona.

*Specimens examined.*—Total number, 20, from localities as follows:

ARIZONA: Wolf Hole (type locality 6 miles north, 12; Kanab Wash (near southern boundary Kaibab Indian Reservation), 1.

UTAH: Saint George, 7.

**Dipodomys ordii cupidineus,** subsp. nov.

Kaibab Kangaroo Rat.

*Type* from Kanab Wash, at southern boundary of Kaibab Indian Reservation, Arizona. No. 243093, ♂ adult, U. S. National Museum (Biological Survey Collection), collected by E. A. Goldman, October 12, 1922. Original number 23384.

*General characters.*—Closely allied to *Dipodomys ordii utahensis*, but general color of upper parts much brighter and richer, near cinnamon-buff instead of dull clay color; hind foot with five toes. Externally resembling *D. o. longipes* and *D. o. richardsoni*, but cranial characters widely different.

*Color.*—*Type* (fresh pelage): Upper parts in general near cinnamon-buff of Ridgway, this color purest along sides and on hind legs, becoming paler on the face and over top of head and back evenly but rather inconspicuously lined with dusky hairs; under parts, forelimbs, hind feet above, supraorbital and postauricular spots, hip stripes and tail at base all around pure white as usual in the group; inner sides of ears clothed with blackish hair; tail beyond extreme base blackish along upper median stripe to tip and along lower median stripe which narrows gradually until interrupted subterminally by a white area continuous with white lateral stripes; soles of hind feet and small isolated spots just above heels on outer sides blackish.

*Skull.*—Essentially like that of *D. o. utahensis*. Compared with that of *D. o. longipes*, the skull is smaller with shorter rostrum, the mastoid and audital bullae are relatively decidedly smaller, and the supraoccipital and interparietal are broader, more widely separating mastoid bullae.

*Measurements.*—*Type:* Total length, 257; tail vertebrae, 150; hind foot, 41. *Skull* (type): Greatest length on median line, 36.4; greatest breadth (between outer sides of audital bullae), 24.9; breadth across maxillary arches, 21.1; least width of supraoccipital (near interparietal), 2.5; maxillary toothrow, 4.7.

*Remarks.*—The geographic range of *D. o. cupidineus* is the Kaibab plateau region of northern Arizona, and adjacent parts of southern Utah. In color this subspecies closely resembles *D. o. longipes* which inhabits similar territory south of the Colorado River, but differs widely in cranial characters as already indicated. The Colorado River and its great canyon evidently form an effective barrier separating the ranges of the two forms.

*Specimens examined.*—Total number, 26, as follows:

ARIZONA: Cane, Houserock Valley, 2; Diamond Butte, 1; Fredonia, 2; Houserock, Houserock Valley, 2; Hurricane Ledge (6 miles north of Mount Trumbull, 1; Kanab Wash (type locality), 1; North Canyon (at edge of juniper belt), 4; Trumbull Mountains (5 miles south of Trumbull Spring), 1.

UTAH: Kanab, 11; Pipe Spring, 1.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE GEOLOGICAL SOCIETY

### 387TH MEETING

The 387th meeting was held in the Auditorium of the Department of the Interior on Wednesday, January 9, 1924, President Wright presiding, and 53 persons present.

Informal communication: FRANK L. HESS.—*Corundum crystals from Bandalierkopf, Transvaal.* Discussed by F. E. WRIGHT.

Program: L. H. ADAMS.—*Behavior of rocks under pressure.* Discussed by Messrs. RICE and BOWIE.

S. R. CAPPS.—*An early Tertiary placer deposit in Alaska.* In the Cache Creek gold placer mining district, in the basin of Yentna River, a western tributary of the Susitna, recent mining developments have disclosed a heavy

deposit of subangular quartz fragments at the base of the Tertiary (Eocene) coal-bearing formation. This quartzose deposit, which contains angular, uneroded gold in minable amounts, lies upon a deeply weathered erosion surface of Mesozoic argillites and graywackes and is overlain by Tertiary sands, shales and lignite, which themselves are buried beneath a heavy mantle of glacial till that also contains some placer gold. The entire section, including 50 feet of subangular quartz, 50 feet of Teritiary sandstone and shale, and 100 feet of glacial till, contains enough gold so that it has all been mined by hydraulic methods.

The layer of subangular quartz fragments at the base of the Tertiary beds and its contained gold are believed to represent a residual accumulation on the exposed surface of the Mesozoic rocks resulting from a long period of late Mesozoic or Early Tertiary erosion. The character of the quartz fragments is the same as that of abundant quartz gash veins and bunches in the Mesozoic rocks, and the subangular shapes of the quartz fragments, as well as the rough and unworn character of the placer gold, indicate a bedrock source near at hand. The quartzose deposit is the base of the Tertiary section at this place, and represents an early Tertiary placer accumulation. The gold of the present stream placers has been derived chiefly from the Tertiary deposits and the glacial till, by post-glacial concentration, and only to a small extent from the original bedrock source through erosion by the post-glacial streams. (*Author's abstract.*)

Discussed by Messrs. HEALD, LEE, ALDEN, SCHRADER, BROOKS, and WRIGHT.

R. S. BASSLER.—*Sinkhole structure in central Tennessee.* The Central Basin of Tennessee underlaid by various Ordovician limestone formations and the surrounding Highland Rim exposing several Mississippian limestones, exhibit a variety of sink-hole phenomena. On the Highland Rim, typical sink-holes are often developed through the formation of caves in the Ordovician limestone and the falling in of the roof of Mississippian limestones with the result that the latter strata now surround the sink-hole in a vertical position. On the western Highland Rim ancient sink-holes are filled by brown iron ore bodies. Further west in Decateur County white phosphate occupies such sink-holes in Silurian limestone. In the northern part of the Central Basin, sink-holes in Ordovician limestone are occasionally completely filled to a depth of 30 or 40 feet by the Early Mississippian Hardin sandstone which elsewhere in the vicinity is only a few inches thick. In Central Tennessee the strata occasionally follow the topography, that is, the same stratum may be found to rise with a hill and then descend to the bottom with it on the other side. This phenomenon, instead of being original structure, may be due to the slumping of the strata because of sink-hole formation. (*Author's abstract.*)

### 388TH MEETING

The 388th meeting, a joint meeting with the Washington Academy of Sciences and the Philosophical Society of Washington, was held in the Auditorium of the Department of the Interior January 23, 1924, President A. L. DAY of the WASHINGTON ACADEMY OF SCIENCES in the chair, and 403 persons present. Dr. T. A. JAGGER, Director of the Hawaiian Volcano Observatory, delivered two addresses:

1. *The Hawaiian volcanoes*, a summary of systematic observations at Kilauea and the salient recent discoveries in volcanology. Illustrated by lantern slides.

2. *The Tokyo earthquake*, a summary of the earthquake and a comparison of its disasterous effects with those of the Sakurajima eruption of 1914. Illustrated by two rolls of motion pictures. Dr. JAGGER visited Tokyo in September, 1923, and obtained possession of an extraordinary film taken the day of the earthquake.

### 389TH MEETING

The 389th meeting was held in the Auditorium of the Department of the Interior February 13, 1924, President Wright presiding and 56 persons present. The Secretary announced the resignation of N. M. FENNEMAN, EDSON S. BASTIN, Miss MARTHA D. BENNETT, and Miss ELSIE PATTERSON.

Program: W. F. FOSHAG.—*Saline playa lakes of the Mojave Desert.* This paper, which was illustrated by lantern slides, was discussed by Messrs. HESS, WHITE, FERGUSON, W. M. DAVIS, and WRIGHT.

SIDNEY PAIGE and W. T. FORAN.—*A reconnaissance of the Arctic coast of Alaska, 1923.* Discussed by Messrs. HESS, HEWETT, and WRIGHT.

### JOINT MEETING

A joint meeting of the society and the WASHINGTON ACADEMY OF SCIENCES was held at the Cosmos Club Thursday, February 21, 1924, President Wright of the Geological Society presiding.

Program: Dr. ALFRED C. LANE of Tufts College.—*The age of the earth and the oceans.*

### 390TH MEETING

The 390th meeting was held in the Auditorium of the Department of the Interior February 27, 1924, President WRIGHT presiding. Attendance 56. The Secretary presented resignations from C. E. LESHER and S. S. VISHER.

Program: PROF. WM. M. DAVIS.—*Gilbert's theory of laccoliths.* The paper outlined Gilbert's analysis of the conditions under which the intrusion of the Henry Mountain laccoliths took place, with special regard to the evidence for the fluidity of the magma at the time of intrusion, and for the limitation of the dimensions of laccoliths by certain mechanical factors. Hence, for Gilbert, a laccolith was not simply a great blister-like mass of instrusive rock, but an intrusive mass that had taken its place in blister-like forms in a special manner.

If the mechanical principles that are exemplified by the regular laccoliths of the Henry Mountains do not explain laccoliths of more irregular form and distribution elsewhere, that should not be taken to prove that Gilbert's relatively simple explanation of the Henry Mountain laccoliths is in error, but rather that an elaboration of his explanation should be proposed, whereby it can be adapted to more complicated occurrences.

The case of intrusive sheets of greater horizontal extent than the limiting diameter of the Henry Mountain laccoliths also calls for special explanation. A factor that Gilbert did not especially consider is the rate of intrusion; if it be imagined that intrusions may take place at a slow, an intermediate, and a rapid rate, perhaps extensive sheets may be the result of slow intrusion; regular laccoliths may be the result of intrusion at an intermediate rate; and irregular laccoliths may be the result of rapid intrusion. (*Author's abstract.*)

Discussed by Messrs. HESS, WRIGHT, WASHINGTON, CROSS, PAIGE, and LAWSON.

Prof. A. C. LAWSON.—*Some geological implications of isostasy.*

Discussed by Messrs. WRIGHT, ALDEN, STOSE, WASHINGTON, DAVIS, and COOKE.

## 391ST MEETING

The 391st meeting was held in the Auditorium of the Department of the Interior March 12, 1924, Vice-President HEWETT in the chair, and 47 persons present. The resignation of ELEANOR F. KNOPF was announced.

Program: J. BRIAN EBY.—*The carbonization of some Colorado coals by igneous intrusion.* The opportunity to study the effects of igneous intrusion on bituminous coal beds is offered by a series of surface and borehole prospects on the Shelton Tract in the northeast corner of the Yampa coal field, Colorado. Nine beds of coal occur overlying a basaltic sill that is approximately 75 feet thick. The coal occurs in 200 feet of sandstone and shale beds, the two most important beds lying at 60 and 170 feet above the sill, and averaging about 4 feet and 8 feet thick, respectively. The area is described by H. S. Gale and N. M. Fenneman in Bulletin 298 of the Geological Survey, page 72.

Fifteen drill holes were put down and surface pits were opened to prospect the coals. E. Shelton, of hayden, owner of tract, reported to writer wells were churn drilled. Dr. T. W. Stanton, who visited the locality in 1905 with Gale, reports that wells were core drilled. It was found that the coals nearest the sill were carbonized or anthracitized and presented many of the physical features of the Pennsylvania anthracite. The correlated well records, making use of the drillers' classification of the coal, indicate that all coal within 60 feet of the sill is anthracitized, that 50 per cent of the coals from 65 to 105 feet above the sill show effects of carbonization, and that coals more than 110 feet above the sill are unaffected.

The sill rock, examined in thin section by C. S. Ross, is a fine-grained olivine basalt, derived apparently from a dry magma that cooled slowly under cover. The overlying sandstone and shale beds, of which the latter predominate, are apparently not affected except for a few inches at the actual contact. Thin sections of a sandstone overlying the sill about 50 feet give no evidence of metamorphism. The fact, however, that the coals are carbonized in places up to 105 feet above the sill emphasizes the sensitive character of carbonaceous deposits to local metamorphism.

An effort was made to account for the irregular upward limit of the anthracitization, but field observations gave no tangible results. The occurrence of lentils of sandstone in shale or lentils of shale in sandstone between the sill and the coal bed would to some extent serve to give the upward limit of anthracitization an uneven or wavy surface. The surface examination of the Shelton tract, which is well timbered country, scarcely justifies this explanation although the rocks involved, middle Mesaverde in age, in adjoining territory exhibit to some extent lenticular character. (*Author's abstract.*)

Discussion by Messrs. CAPPS, SAMPSON, WHITE, SPENCER, and FORAN.

H. G. FERGUSON and S. H. CATHCART.—*Major structural features of some western Nevada ranges.* The portions of the Hawthorn and Tonapah quadrangles covered by the present reconnaissance comprise an area of about 5,000 square miles of basin range country lying just east of the Sierra Nevadas. As is common within the Basin Range Province, the principal surface features are a series of ranges separated by desert valleys. The eastern and the western ranges have a northerly trend; in the central part they have a sinuous northwest trend; while in the southern part the trend is east.

The rocks of the region range in age from Cambrian to Quarternary. The Paleozoic is represented by the Cambrian, Ordovician, Devonian, Pennsylvanian, and Permian. At least three marked unconformities are recognized; namely, between the Triassic and Permian, between the Permian and Pennsylvanian, and between the Pennsylvanian and Devonian. Angular discordance is noted only at one locality; between the Permian and Ordovician. The Carboniferous is represented in this region by less than 300 feet of strata. To the northeast and to the south, it is much thicker. At Eureka, it is 18,000 feet; in the Inyo region, it is more than 8,000 feet thick.

The Mesozoic is represented by sedimentary and volcanic rocks of Triassic and Jurassic age and by plutonic rocks of late Jurassic or Cretaceous age. One pronounced angular unconformity is observed within the Mesozoic, probably within the lower Jurassic. Plutonic rocks chiefly quartz monozonite occur in isolated areas throughout the region and are believed to represent a single epoch of intrusion.

The Tertiary and Quaternary are represented chiefly by volcanic flows with which occur lacustrine sediments and alluvial deposits. The subdivisions of Cenozoic which are recognized are: Volcanics of pre-Esmeralda age, the Esmerlada formation consisting in large part of lake beds, of upper Miocene age, volcanics of late Esmeralda time, Pliocene lacustrine sediments, Pliocene andesites, basalt of late Pliocene or Pleistocene age and alluvium of Pleistocene and recent age. The Tertiary is unconformable on the Mesozoic. Thre major unconformities are recognized within the Tertiary; the oldest volcanics were deformed before the deposition of the Esmeralda, the Esmeralda was deformed before the extension of the andesites and a widespread erosion surface was developed upon the andesite and older rocks before the basalts were extruded.

Faulting is the dominant structural feature of the Tertiary rocks. The volcanics and sedimentary beds are tilted at angles of 20° or less but in general are nowhere highly folded. Pre-Tertiary rocks are everywhere highly folded and in places compressed and overturned. Overthrusting was observed at several localities. The major deformation has involved the Lower Jurassic sediments but not the plutonic rocks, and is believed to have occurred late in the Jurassic. The structure of the sedimentary rocks is independent of the intrusives. The intrusives in general truncate pre-existing folds. The trend of these structures is in general oblique or normal to the trend of the present ranges showing almost complete lack of concordance between structures of Tertiary and pre-Tertiary time.

The present topography is dominantly the result of faulting in 4 directions; movement having taken place at different times from a date prior to the upper Miocene up to the present.

The major faults show a rough pattern. Northerly faults dominate in the easterly portion of the area; northeasterly faults are found along the northern border; northwesterly faults, parallel to the Sierra scarp, are found in the west; and there is a small group of westerly faults in the southwest. This herringbone pattern is found too widely and is too pronounced to be accidental. It may be dependent on the major line of pre-Tertiary structure. The faults differ in age, but movement on the most recent faults seems in most cases to a revival along older fault lines.

For the faults of the oldest group, the evidence is weakest. Near its contact with the older rocks, the Esmeralda formation contains coarse fanglomerates which grade out into fine grained material towards the valley. This implies deposition in basins whose walls had considerable relief. Where

contacts of this type show alignment parallel to later more definite faulting and at the same time not in accord with the structure of the older rocks it is assumed they mark the approximate position of buried fault scarps along which there has been no revival of movement. Since the Esmeralda in places exceeds 1,000 feet, deposition in sinking basins is implied.

An old erosion surface is present in nearly all of the ranges. This is assumed to be of late Pliocene age. Faults which are truncated by this surface belong therefore to the first two groups.

The Pleistocene faults displace this older surface and consequently preserve their topographic expression. Those whose activities ceased in comparatively early Pleistocene time do not show the facetted spurs characteristic of the more recent faults, and the retreat of the range front from its original position is shown by the presence of a rock bench or pediment whose width and definition varies with the resistance of the rock.

The most recent faults have caused the type of range front most commonly associated with basin range structure. The streams crossing the scarp flow in narrow box canyons near the front with widening valleys headward. Stages of the faulting are in many places indicated by terraces in the canyons. The interstream areas present sharp facetted slopes reaching the main valley without the interposition of a pediment. Movement along individual scarps was variable. In the Toyabe range the northern streams cascade over rock to the edge of the range while those in the south are gravel choked at their mouths. Major movement on the Wassuk front seems to have been more recent than on the Toyabe because the greatest depression in the valley is close to the scarp while in the valley east of the Toyabe, it is nearly along the center.

The remnants of a broad bench, present at different elevations on the recent fronts of the Toyabe, Pilot, and Wassuk ranges, is evidence that there was a definite pause between early and later Pleistocene faulting.

In certain cases movement along the same fault line took place in opposite directions at different times and places. The clearest evidence of this is the fault extending northwesterly from the west front of the Pilot Range. Here, movement in Pleistocene time along the southern half had its downthrow on the west. The same fault continues diagonally across the Gillis range but without topographic expression other than the development of fault line valleys. Here the relations of granite and rhyolite indicate downthrow on the east. Since in the southern part the older faulting, if any, is masked by the later, it could not be certainly determined whether the newer faulting represents movement in a reverse direction to the older or whether this is an example of a hinged fault in which recent movement has been confined to the southern block.

There is a suggestion of similar action along the San Antonio and Toyabe range fronts. Here movement on both blocks seems to have been initiated in Pleistocene time, and hinge faulting is the more probable explanation.

In only a few cases can the absolute direction of movement be determined. The old erosion surface, which is our guide in estimating relative movement, must be used with caution as an absolute datum plane. There is no evidence that the region had free access to the sea or a humid climate in late Tertiary or Pleistocene times. Under conditions of inclosed basins and semi-aridity it is possible for a large area to be worn down to an old age topography dependent upon a base level far above the sea or upon several independent base levels at varying elevations. It is moreover likely that earlier regional uplift of which the Sierra gives evidence extended over a part of the Basin Range province.

Study of individual blocks, however, does suggest absolute upward movements for certain horsts and absolute depression for certain graben, at least during Pleistocene faulting.

In the earlier stage of the Pleistocene the Pilot range was elevated absolutely as a horst since the pediment on the east accords in elevation with the bench or hanging pediment on the west, and both are about 2,000 feet below the level of the old surface. If the movement was absolutely down on each side of the range it would require two simultaneous but unconnected faults of equal displacement.

On the other hand the more recent faulting confined to the west side of the range seems to have been absolutely downward, for the new scarp has a maximum height of 1,000 feet yet the bench and pediment are not tilted and there is no compensating recent fault on the east. Whether the downthrown block was rotated or whether the whole area between the recent Pilot and Wassuk faults is to be considered a graben was not determined.

The Pilot block therefore may be considered an absolutely elevated horst with later downward movement on one side and without rotation. The recent fault block of the Toyabe and Wassuk ranges however shows tilting of the old surface.

Although faulting is the dominant feature in the present ranges, there is also evidence of flexures of late Tertiary to Recent age. A detailed study of the individual fault blocks shows cases of faults dying out into flexures and much warping accompanying faulting. (*Authors' abstract.*)

Discussed by Messrs. BRYAN, STOSE, W. M. DAVIS, MATTHES, LAWSON, G. R. MANSFIELD, KEITH, and SPENCER.

## 392D MEETING

The 392d meeting was held in the Auditorium of the Department of the Interior March 26, 1924, President WRIGHT presiding, and 44 persons present. The secretary announced the election of Dr. WALTER R. SMITH, U. S. Geological Survey, and the resignation of Dr. PENTTI ESKOLA.

Program: CHARLES BUTTS.—*The Birmingham overthrust in central Pennsylvania.*

Discussed by Messrs. KEITH, STOSE, and SOSMAN.

F. E. MATTHES.—*Hanging side valleys of the Yosemite and the San Joaquin Canyon.* Detaile l study of the physiographic features of the Yosemite region some years ago led the author to conclude that the hanging valleys from whose mouths pour the waterfalls for which the Yosemite is famed, belong to three separate sets situated at different levels one above another. Also, that these three sets are not of contemporaneous origin but are products of successive morphogenic events.

The highest and oldest set of valleys, it appears, was left hanging as a result of the rapid trenching of the main valley by the Merced River, when that stream was rejuvenated by the first great uptilting of the Sierra block, presumably early in the Pliocene epoch. The middle set was carved in the ensuing cycle of erosion and was left hanging in its turn by the renewed trenching of the main valley by the Merced in consequence of the second great Sierra uplift, presumably about the close of the Pliocene. The lowest set of hanging valleys was carved during the next cycle of erosion and was left hanging, apparently, as a result of the overdeepening and widening of the main chasm by the Pleistocene glaciers. The older hanging valleys have remained preserved owing to the exceedingly resistant nature of the massive granite which prevails in the Yosemite region.

The key to this analysis is found in the lower Merced Canyon which, although unglaciated, has a set of imperfect hanging valleys. This set, it was found by a careful reconstruction of the former profile of the Merced to which these valleys were graded, corresponds to the middle set of the Yosemite region. Unfortunately, a complete comparison between the Merced Canyon and the Yosemite region is not possible, owing to the fact that the metamorphic rocks through which the former is laid are much less resistant to erosion than the massive granite of the Yosemite region and are now so thoroughly dissected that no hanging valleys of the upper set remain preserved on them. Again, the comparison is unsatisfactory because the boundary between the granite and the metamorphic rocks happens to coincide with the extreme limit reached in the canyon by the Pleistocene ice. For these reasons it was deemed desirable to institute a comparison with the San Joaquin Canyon, which has passed through the same morphologic history but is carved in essentially massive granite through its length.

Inspection of the San Joaquin Canyon in 1921 and 1923 has revealed the existence throughout its unglaciated lower part and as far up in its glaciated middle part as the Pleistocene gorge cutting has progressed, of two sets of hanging side valleys that correspond in elevation to the two higher sets found in the Yosemite region. These features are in fact splendidly developed to within a few miles of the foothills, and the analysis made in the Yosemite region accordingly stands fully confirmed.

The lowest set of hanging valleys also is represented in the San Joaquin region, but there are some features in the lower part of the canyon that would seem to indicate that this set too is primarily of stream cut origin and only secondarily of glacial origin. Glacial erosion would thus seem to be minimized, but this is true only in the lower and middle parts of the canyon. In the upper parts, which were subjected to more frequent and more prolonged glaciation, the excavational effects produced by the ice are considerable. (*Author's abstract.*)

### 393D MEETING

The 393d meeting was held in the Auditorium of the Department of the Interior April 9, 1924, President WRIGHT presiding and 45 persons present. The question of place of meeting for the following year was discussed by Messrs. G. R. MANSFIELD, MENDENHALL, CAPPS, ALDEN, HEWETT, CROSS, and COLLINS. A rising vote showed 24 in favor of meeting at the Cosmos Club; no one voted to continue to use the Auditorium of the Department of the Interior.

Program: HAROLD T. STEARNS.—*Igneous geology of the Mud Lake Basin, Idaho.* The Mud Lake basin is situated in the northeastern part of southern Idaho and comprises an area of about 2,500 square miles. The area is bounded on the north by the Continental Divide of the Rocky Mountains, and on the east by Big Bend Ridge. The basin forms a part of the Snake River lava plain.

The purpose of the Mud Lake investigation was to determine the origin and supply of Mud Lake, a lake covering 31,000 acres of land which came into existence about 1900. The lake originated from irrigation on Egin Bench 20 miles to the east.

Thick beds of Triassic and Cretaceous sandstone were discovered along the, Continental Divide during the investigation.

Following the building of the Rocky Mountains, a cycle of erosion developed the Idaho peneplain. Upon this peneplain the first lava was extruded.

Some time during the Miocene the first volcanic eruptions began in the region. Eruption after eruption occurred and thick flows of rhyolite were extruded. These flows were very extensive and may have obliterated the entire Miocene landscape of the region. The acidic eruptions continued into the Pliocene for camel bones were found in the ash of one of the cones. If the age correlation is correct for the rhyolites of western Idaho, there has been a shifting eastward of the loci of eruption from Miocene to Pliocene time.

A few small basic eruptions occurred during this period.

In late Pliocene time another period of erosion began which culminated in the peneplain preserved on the top of Big Bend Ridge.

At the close of this period of erosion, andesitic lavas were extruded from numerous small vents along the foothills of the mountains. These eruptions were intermediate both in time and space between the basalt of the Snake River plain and the rhyolite of the adjacent mountains.

The Pleistocene and Recent were occupied by the pouring out of floods of basalt from single craters, crater chains, and fissures.

Three types of cones were described:

1. Scoria cones. About 150 were mapped. They range in height from 25 to 1,000 feet.

2. Dome-shaped basalt cones. Some of these cones are only 300 feet high but cover 100 square miles, indicating that several cubic miles of lava came from a single vent. About 30 were mapped. Morgan Crater, the largest crater in the region, is 1 mile in diameter and about 200 feet deep.

3. Tuff Cones. There were only 5 tuff cones found in the region. They are the Menan Buttes and occur in a straight line 7 miles long. They were probably due to basic magma which, in ascending to the surface through a fissure, came in contact with the water in the alluvial fan of Snake River.

Numerous surface features of the lava surfaces were described. About 30 lava tunnels were mapped. (*Author's abstract.*)

Discussion: F. E. WRIGHT, G. R. MANSFIELD, W. C. ALDEN, F. E. MATTHES, O. E. MEINZER, and R. B. SOSMAN.

C. W. GILMORE.—*The Dinosaur National Monument and its fossils.* In this paper a brief historical review of the establishment and work done at the Dinosaur National Monument, Utah, was presented, followed by an account of the operations carried on there by an expedition from the U. S. National Museum. Attention was directed to the fact that this fossil deposit is the most extensive and productive of any ever found in the Morrison formation. The character of the sediments and the manner of deposition of the dinosaurian fossils were briefly explained, and it was pointed out that the National Museum expedition was successful in having secured sufficient material for a good skeletal mount of *Diplodocus* that will exceed 80 feet in length with a height at the hips of over 14 feet.

In concluding this paper, slides and one reel of moving pictures were used to illustrate the methods employed in collecting these large fossil remains. (*Author's abstract.*)

### 394TH MEETING

The 394th meeting was held at the Cosmos Club, Wednesday evening, April 23, 1924, at 8 o'clock, President WRIGHT in the chair and 33 persons present. The secretary announced the election of STEPHEN G. MASON to membership.

Program: H. E. MERWIN.—*Note on the hydrated sulphates of magnesia in hot springs.* In samples of hot springs deposits collected and analyzed by Dr. E. T. Allen four different crystalline substances were determined optically. Chemically, all seemed to be hydrates of magnesium sulphate, but only one such hydrate has been described optically as a mineral. Studies of the system $MgSO_4$-$H_2SO_4$-$H_2O$ and of the thermal dehydration products of $MgSO_4$-$7H_2O$ were carried on, and the tetra- and penta-hydrates found to be new minerals, and also the optical properties of the hexahydrate were determined (*Author's abstract.*)

H. D. MISER.—*A new areal geologic map of Oklahoma.* A new areal geologic map of Oklahoma to be printed in colors is being prepared by the United States Geological Survey in cooperation with the geologists in Oklahoma. The map compilation which was assigned to me consisted mostly in making use of available information from numerous sources; very little field mapping was done except during several field conferences with other geologists. Unpublished maps obtained from scores of commercial geologists and companies cover about one-third the State; unpublished maps from the Federal and State geological surveys cover the second third; and published maps cover only the last third. The new State map will therefore present new mapping for fully half the State. The total number of used maps that have been obtained from all sources is about 900.

Some of the most interesting features displayed by the new map are as follows:

1. The connection of the northern Oklahoma Pennsylvanian section with the Arbuckle section.
2. A great synclinal basin in the Permian Red Beds lying north of the Wichita Mountains.
3. A westward extension of the Wichita Mountain uplift into the panhandle of Texas.
4. An en echelon arrangement of the structural axes of the Wichita and Arbuckle mountains and of the intervening area.
5. A broad crescent-shaped pattern of the Boggy shale (Pennsylvanian) more than a hundred miles in length, with one point of the crescent touching the southwest end of the Ozark region and the other point touching the north side of the Arbuckle Mountains.
6. Numerous thrust faults with a total horizontal displacement of many miles in the closely folded rocks of the Ouachita Mountains.
7. Several long lines of en echelon faults in northeast central part of State.
8. A striking radial arrangement of the color patterns for the entire State, with the Arbuckles occupying the center of the hub. (*Author's abstract.*)

Discussed by Messrs. LAWSON, WHITE, MENDENHALL, SPENCER, and KEITH.

E. M. SPIEKER.—*Stratigraphy and structure of the Wasatch Plateau.*

Discussed by Messrs. THOM, SEARS, REESIDE, SPENCER, and LAWSON.

C. WYTHE COOKE, *Secretary.*

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